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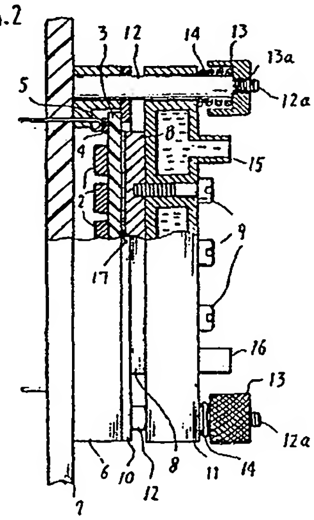
(54) Liquid cooling system for integrated circuit chips.

(57) A cooling system for an electronic system comprises a connector (6) mounted on a panel (7) and an integrated circuit package (3, 2) removably connected to the connector by a mounting frame (10). A layer of heat conductive bonding material (17) is provided between the package and a heat conductive member (8) which is removably secured to a water-cooling heat exchanger (11). A plurality of guide posts (12) are secured to the panel (7) for holding the heat exchanger. Each guide post is formed with an externally threaded portion (12a) on to which a thumb nut (13) is screwed. A coil spring (14) is provided between each thumb nut and the heat exchanger to exert a predetermined amount of contact pressure between the connector (6) and package (3, 2) and take the weight of the heat exchanger (11).

FIG.2



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Description

"Liquid Cooling System for Integrated Circuit Chips"

The present invention relates to a liquid cooling system for integrated circuits.

A prior art cooling system for large scale integrated circuit chips as shown and described in United States Patent 4,072,188 issued to E. A. Wilson et al involves the use of a liquid coolant heat exchanger having a flexible, heat conductive wall. The heat exchanger is mounted so that the flexible wall is in close proximity to a surface of the substrate on the other surface of which the integrated circuit chips are mounted. A low thermal impedance contact is made through the flexible wall of the heat exchanger between the substrate to be cooled and the coolant flowing through the heat exchanger because of the pressure of the coolant in the heat exchanger.

The flexible wall of the heat exchanger is formed of copper and has a thickness in the range between 0.05 mm and 0.25 mm. Because of the small thickness of the flexible wall, the pressure of the coolant in the heat exchanger reaches a limit which is unacceptably lower than is required to maintain the temperature of the integrated circuit chips in the micropackage below their maximum operating temperature. In addition, during replacement or repair greatest care must be taken to ensure against possible breakage of the thin flexible wall of the heat exchanger, which could lead to the leakage of liquid coolant to micropackages.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a liquid cooling system for integrated circuit chips which is capable of maintaining their operating temperature below their maximum operating temperature and of ensuring against possible leakage of liquid coolant during replacement or repair of a micropackage.

Specifically, the cooling system for an electronic system comprises a connector mounted on a panel, an integrated circuit package removably connectable to the connector, a mounting frame for mounting the package into contact with the connector, a heat exchanger means provided with inlet and outlet means to permit liquid coolant to flow through the heat exchanger, and a layer of heat conductive bonding material for bonding the heat exchanger means to the package to provide a low thermal resistance contact therebetween. A plurality of fastening means are mounted on the panel for removably holding the heat exchanger means.

Preferably, each of the fastening means comprises a guide post having a shaft portion and an externally threaded portion, a nut having an internally threaded portion engaging with the externally threaded portion, and a coil spring between the nut and the heat exchanger means. The coil spring exerts a predetermined amount of pressure when the nut is tightened to the shaft portion. The heat conductive layer is preferably composed of nonfluidic silicone compound which is surrounded by a wall of silicone rubber.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be described in further detail with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view of an embodiment of a liquid cooling system of the invention;

Fig. 2 is a view in section of the embodiment of Fig. 1; and

Fig. 3 is a view in section of another embodiment of the invention.

DETAILED DESCRIPTION

Referring to Figs. 1 and 2, there is illustrated a multichip integrated circuit assembly or micropackage 1 which comprises a relatively large number, approximately 80, of large scale integrated circuit chips 2 mounted on one surface of a square printed circuit board or substrate 3 which is made of electrically nonconductive ceramic material such as aluminum oxide. The chips and details of the printed circuit are not illustrated since they form no part of the invention. Along the edges of the substrate 3 is formed a plurality of electrical contacts 4 which engage contacts 5 of connector 6. Connector 6 is fixedly mounted on a panel 7 which also has a printed circuit to permit the large scale integrated circuits 2 to be interconnected to form an electronic system.

To remove heat from micropackage 1 a surface of the substrate 3 opposite to integrated circuits 2 is in contact with a heat conductive member 8 which is formed with threaded screw holes 8a. Heat conductive member 8 is composed of a metallic substance such as copper or aluminum or a nonmetallic substance such as beryllium oxide or aluminum nitride. To ensure low thermal resistance contact between the substrate 3 and heat conductive member 8, the latter is cemented to the substrate by a layer 17 of heat conductive bonding material such as solder or silver-containing epoxy resin. If solder is used, the contact surface of substrate 3 should be metallized prior to soldering. Clearances which would otherwise occur between the heat conductive member 8 and substrate 3 are filled with the bonding material 17.

A water-cooling heat exchanger 11 is in face-to-face, low thermal resistance contact with the heat conductive member 8 by means of screws 9 which extend through holes 11a and are threadably engaged with screw holes 8a. At each corner of connector 6 is provided a guide post 12 formed with an externally threaded tip 12a. Each of the guide posts 12 extends through a corresponding hole 10a of a mounting frame 10 and a corresponding hole 11b of the heat exchanger 11. Mounting frame 10 holds the micropackage 1 in pressure contact with the connector 6. Each thumb nut 13 has an internally threaded hole 13a threadably engaged with the externally threaded tip 12a of a corresponding one of the guide posts 12.

Each thumb nut l3 has an internal recess in which a coil spring l4 is disposed. The coil spring l4 exerts a predetermined amount of presssure on the heat exchanger ll when the thumb nut l3 is tightened to the shoulder portion of the guide post l2 so that the weight of the whole unit (of which the greater portion is accounted for by the weight of the heat exchanger ll and conductive member 8) is taken by the guide posts l2 via springs l4. Since each of the holes llb is sized slightly greater than the cross-section of the shaft portion of each guide post l2, and since the position of contacts 4 of the micropakcage with respect to the contacts 5 of the connector 6 is determined by the mounting frame l0, a shearing stress would occur between the substrate 3 and heat conductive member 8 due to the weight of the heat exchanger ll. However, the compression by springs l4 not only eliminates the shearing stress which would cause the heat conductive member 8 and substrate 3 to separate from the bonding layer l7, but also prevents excessive pressure between contacts 4 and 5.

To maintain the heat conductive member 8 and substrate 3 in a fixed configuration under changing temperature, it is preferred that heat conductive member 8 have a thermal expansion coefficient substantially equal to the thermal expansion coefficient of substrate 3. Therefore, if the substrate 3 is formed of an aluminum oxide ceramic, the heat conductive member 8 comprises molybdenum and tungsten or a sintered block of a mixture of such material as particles of copper. Water-cooling heat exchanger ll has a plurality of partitions, not shown, which are staggered to form a meandering passageway between a water inlet l5 and an outlet l6.

In operation, heat generated by integrated circuits 2 are conducted through the substrate 3, layer l7 and heat conductive member 8 to the heat exchanger ll. Water is admitted through the inlet l5 to outlet l6 of heat exchanger ll to transfer thermal energy from the heat conductive member 8 to cooling water. The total value of thermal resistances of the water cooling system between the integrated circuit chips 2 and heat exchanger ll is made significantly small by establishing pressure contact between the substrate 3 and heat conductive member 8 by the intermediate heat conductive layer l7. Since the heat exchanger ll can be operated under high liquid pressure, the liquid cooling system of the invention operates at high efficiency.

When replacement or repair is required for micropackage l, loosening of nuts l3 allows the heat exchanger ll with heat conductive member 8 attached thereto to be removed from the substrate 3 without the danger of water leakage, allowing the micropackage l to be disconnected from connector 6.

Fig. 3 is a modified embodiment of the invention in which a nonfluidic layer 20 of non-cured thermally setting heat conductive silicone compound is laid on a surface of the substrate 3 opposite to the integrated circuit chips 2. This heat conductive layer 20 is surrounded by a wall of silicone rubber 2l which serves as a bond between the heat conductive member 8 and the substrate. To impart thermal conductivity, the silicone compound is a mixture of silicone oil and powder of beryllium oxide or aluminum nitride, or any other thermally conductive materials. Heat conductive layer 20 provides an efficient means for extracting heat from the substrate 3 and conducting it to the heat conductive member 8. During replacement of a micropackage, the thumb nuts l3 and screws 9 are loosened to remove the heat exchanger ll from the heat conductive member 8.

Claims

l. A cooling system for an electronic system comprising:

a connector mounted on a panel;

an integrated circuit package removably connectable to said connector;

a mounting frame for mounting said package into contact with said connector;

a heat exchanger means provided with inlet and outlet means to permit liquid coolant to flow through said heat exchanger;

a layer of heat conductive bonding material for bonding said heat exchanger means to said package to provide a low thermal resistance contact therebetween; and

a plurality of fastening means mounted on said panel for removably holding said heat exchanger means.

2. A cooling system as claimed in claim l, wherein each of said fastening means comprises a guide post having a shaft portion and an externally threaded portion, a nut having an internally threaded portion engaging with said externally threaded portion, and a coil spring between said heat echanger means and said nut, said coil spring exerting a predetermined amount of pressure on said heat exchanger means when said nut is tightened until it reaches said shaft portion.

3. A cooling system as claimed in claim l, wherein said heat exchanger means includes a heat exchange unit having a plurality of throughholes and a heat conductive member having a plurality of screw thread holes in positions corresponding to said throughholes for detachably connecting said heat exchange unit and said heat conductive member together by screws, said heat conductive member being in low thermal resistance contact with said integrated circuit package.

4. A cooling system as claimed in claim l, wherein said layer comprises nonfluidic silicone compound and a wall of silicone rubber surrounding said silicone compound layer, said slicone rubber wall bonding said integrated circuit package to said heat exchanger means.

5. A cooling system as claimed in claim 3, wherein said layer comprises nonfluidic silicone compound and a wall of silicone rubber surrounding said silicone compound layer, said slicone rubber wall bonding said integrated

circuit package to said heat conductive member.

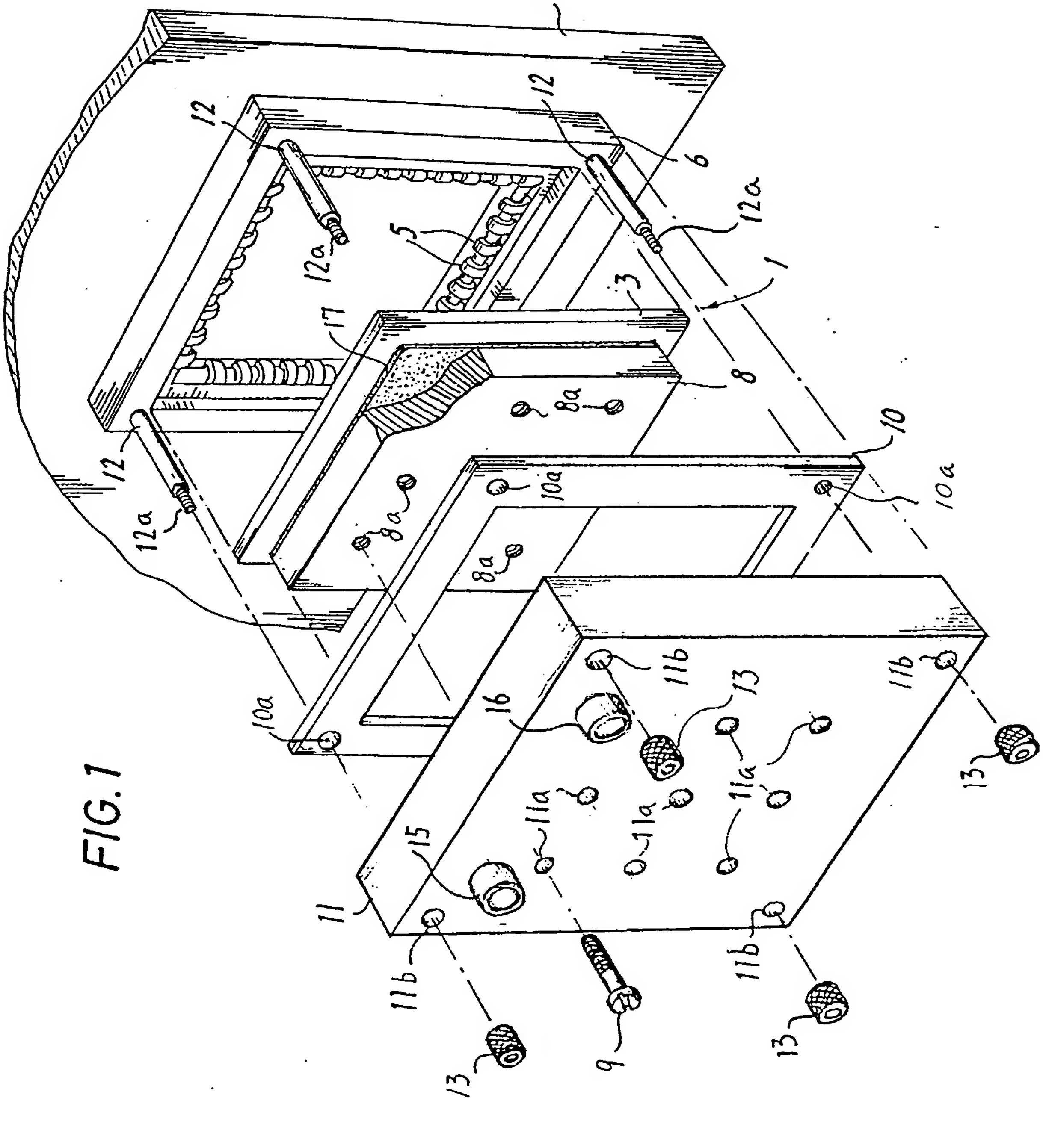

FIG.1

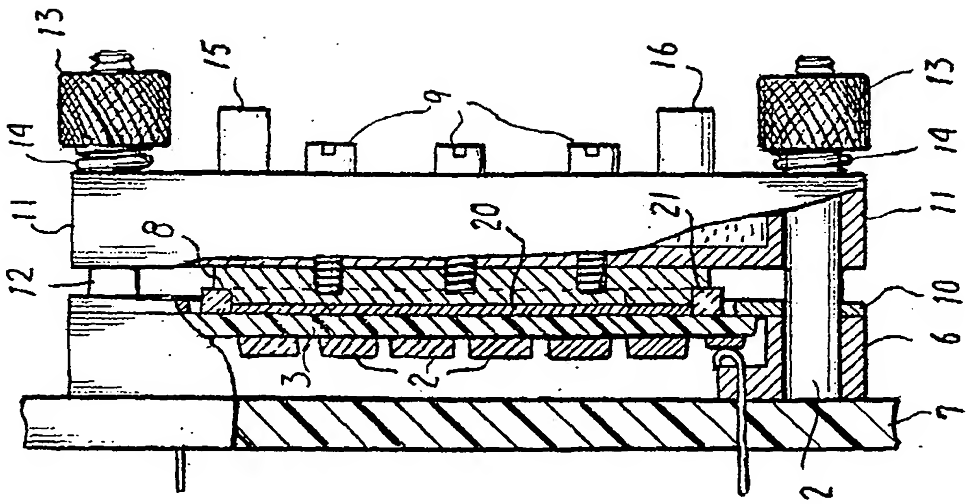
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FIG.3

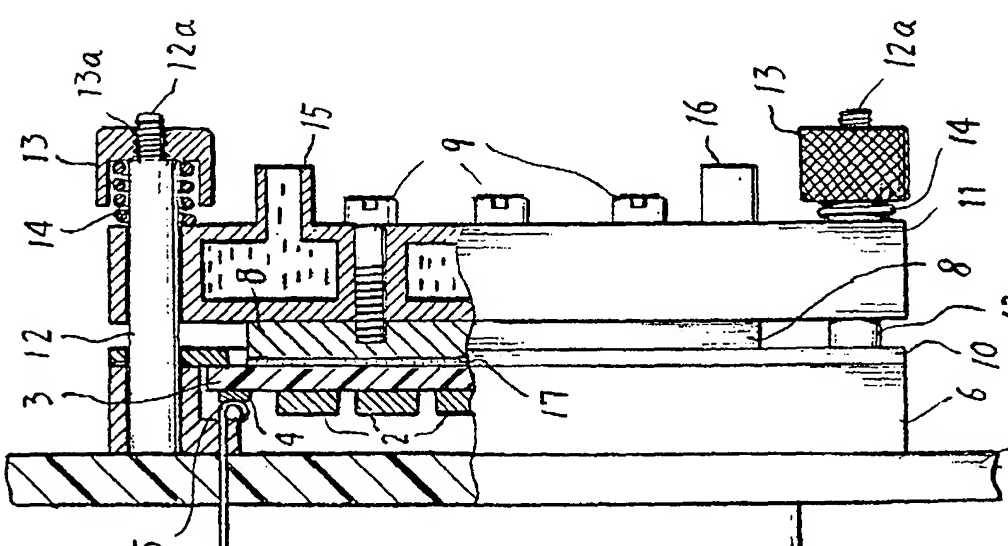
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FIG.2